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VOLATILITY AND GROWTH

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Abstract

The issue about the association between volatility of output growth and output growth has been subject of research among economists. Some economists found negative association, while others found positive association. If one reads through this literature he will find out that there are many reasons to believe that there exist positive association between volatility and growth, and so there are as many reasons to believe that there exists negative association between volatility and growth. This paper proves that there exists positive association between volatility and growth on a large sample of pooled cross-country data (from all geographic regions). The inclusion of other variables in the models especially quality of institutions does not seem to reduce volatility. Inclusion of macroeconomic imbalances (Black Market Premium), and trade (Real/Current openness), does not affect volatility much but also does not affect GDP growth neither, since this variables lack statistical significance. Other variables from the neo-classical function (human capital, initial output, physical capital (investment), and convergence) affect GDP growth as expected.

Keywords: Volatility, Growth, Macroeconomic imbalances, Institutional quality, Economic geography
JEL code: O40, E32, O43

1. Introduction

There are many reasons one to believe that there exist positive relationship between volatility and growth, but also there exists many reasons to believe that the relationship is negative. Fischer, (1987), pointed out that countries may choose between high variance, high expected returns technologies, or low variance and low expected returns technologies[1]. Kormendi, and Meguire (1985), find out in their study that higher volatility (higher standard deviation of growth rate of output) is associated with

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[1] Black, Fischer,(1987), ***Business cycles and equilibrium***. Cambridge, MA: Blackwell

higher mean growth rates. Grier, and Tullock (1989)[2], just confirm the result of positive association between GDP growth and the standard deviation of GDP growth. In one of their regressions a one standard deviation increase in standard deviation of GDP growth is associated with additional 0.17 percentage point of average growth. On the other hand there exist many studies that point out to a negative relationship between output growth and standard deviation of the output growth, i.e. volatility. Ramey and Ramey (1995), is an example of a study where explicitly it is shown that there exists negative relationship between growth of output volatility and GDP growth on a sample of 92 countries, a well a sub-sample of 24 OECD countries. The notion that increased volatility can lower the investment was posed by Bernanke, (1983)[3].If the investors know about the irreversibilities in investment[4], then increase volatility will lead to lower investment. Ignorance of the investor is source of risk and may cause volatility. The distinction between uncertainty (reducible ignorance) and risk (irreducible ignorance), was first made by Frank Knight (1924)[5]. So, in this paper we first explain the theoretical foundations of the econometric model that we are going to use later, and methodology and data that are being used for the estimation. The result ultimately is positive association between output volatility and growth which this paper puts in a group of studies that find positive result between standard deviation of growth and growth of GDP per capita.

1. From Theoretical model to Econometric model

Shock in the economy, as process is linear Markov process:

$$s_{t+1} = 1 - \rho + \rho s_t + \varepsilon_{t+1} \qquad (1)$$

ρ are the time preferences of the economic agents, if with ρ consumers valuate current consumption with 1- ρ consumers valuate the future consumption from which the future shock in the economy depends. While ε_{t+1} are the usual white noise, residuals of the regression.Standard deviation of the

[2] Grier, Kevin B. and Tullock, Gordon. ***"An Empirical Analysis of Cross-National Economic Growth, 1951-80."*** Journal of Monetary Economics, September 1989, 24(2), pp. 259-76.

[3] Bernanke, Ben S**. *"Irreversibility, Uncertainty, and Cyclical Investment."*** Quarterly Journal of Economics, February 1983, 98(1), pp. 85-106.

[4] Irreversibility of investment comes from the notion that most investment are irreversible in a sense that once investment is being made it cannot be transformed into unlike tool without loss of economic value.

[5] Knight, Frank,(1933), ***Risk, Uncertainty, and Profit,*** London.

shock is, given by the expression $\sigma_s = \frac{\sigma_\varepsilon}{\left[(1-\rho)^2\right]^{1/2}}$, where σ_ε is the standard deviation of the innovation. There exist two ways to increase the risk, if the σ_ε increases, and if ρ increases. Older generation representative,t+1,will spend

$$c_{t+1} + k_{t+1} + h_{t+1} \leq s_t A k_{t+1}^{\alpha} (n_t h_t)^{1-\alpha} + (1-\delta)k_{t+1} + (1-\delta)h_{t+1} \qquad (2)$$

Expected value maximization is given by the expression:

$$E\left[\frac{c_t^{1-\sigma}}{1-\sigma} + \beta \frac{(\gamma s_{t+1} k_{t+1})^{1-\sigma}}{1-\sigma}\right] \qquad (3)$$

Here γ is the part of the income of older generation, and if the two generations spend equally, than it represents middle income value[6]. Marginal utility of c_t is equal to k_{t+1} .This is the first condition for utility maximization, and in such a case;

$$c_t^{-\sigma} = \left(\beta\gamma^{1-\sigma} E\left(s_{t+1}^{1-\sigma}\right)\right) k_{t+1}^{-\sigma} \qquad (4)$$

In the equilibrium the ratio of savings and consumption is $\frac{k_{t+1}}{c_t} = \varphi$ .Or,

$$\varphi = \left(\beta\gamma^{1-\sigma} E\left(s_{t+1}^{1-\sigma}\right)\right)^{1/\sigma} \qquad (5)$$

Growth of the economy depends positively of the following ratio because $\frac{y_{t+1}}{y_t} = s_{t+1} * \gamma$, and the expected value of the shock equals technology $E(s_t) = A$:

$$1 + g = E\left(\frac{y_{t+1}}{y_t}\right) = \frac{\varphi}{\varphi + 1} A(1-\gamma) \qquad (6)$$

If the expression $\frac{y_{t+1}}{y_t} = s_{t+1} * \gamma$, is in logarithms we will get:

$$\ln\left(\frac{y_{t+1}}{y_t}\right) = \ln s_{t+1} + \ln \gamma \,, \qquad (7)$$

[6]Growth rate of such an equilibrium is $\frac{y_{t+1}}{y_t} = s_{t+1} * \gamma$

Expected sign before $\ln s_{t+1}$, shock in the economy or volatility that maybe presented as $\ln \sigma$. Empirical literature is ambiguous and some papers opposite from the result in the theoretical exercise they find negative association between economic growth and volatility (standard deviation).Empirical equation estimated by Ramey and Ramey (1995)[7], is presented in the following functional form:

$$\ln\left(\frac{y_{t+1}}{y_t}\right) = \beta_0 + \beta_1 \ln(\sigma) + \beta_2 \ln\left(\frac{I}{\gamma}\right) + \beta_3 n + \beta_4 h_t + \beta_5 \gamma_t + u \quad (8)$$

Here, $\frac{I}{\gamma}$ are the average investments to GDP, while h_t is the initial human capital, while γ_t is the initial per capita GDP. Ramey and Ramey result (1995), is opposite from the *apriori* knowledge, and the sign between volatility of output, and growth of output is negative[8]. While, n is population growth, and u are the white noise or the regressions residuals. If $\sigma > 1$, the model can accommodate to positive association, between volatility and growth, Kormendi, Mequire (1985)[9]. The sing of the increased uncertainty (volatility) varies with preferences of the parameters. Ramey and Ramey (1995), in their regression on 92 countries, they measure aggregate volatility with the specific standard deviation of the average growth for each country, for the period 1960 -1992.Negative correlation is insignificant, when in the regression wecontrol for OECD countries. Aghion,Angeletos, Banerjee, Manova (2005),they find negative association between volatility and growth, by they control for private credits, as an indicator of the financial development of the country, and total investment ratio with GDP[10].Expected value of the utility function that shows relative aversion to risk is given with the following expression:

$$E_t U(c_{t+1}) = \int_0^1 \log(c_{t+1}^p) dp \quad (9)$$

[7] Ramey, G., and V. Ramey. (1995). "***Cross-Country Evidence on the Link between Volatility and Growth***." American Economic Review, 85, 1138–1151.

[8]Negative association between volatility and growth exists if $0 < \sigma < 1$

[9]Kormendi, R. C. and P. G. Meguire. 1985. "***Macroeconomic Determinants of Growth: Cross-Country Evidence***." *Journal of Monetary Economics* 16 (September): 141–163.

[10]Aghion P, Angeletos G, Banerjee A, Manova K.(2005), ***Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment***, Harvard University Department of economics.

Here, c_{t+1} is the consumption of the economic agents in the periodt+1,when the price *p*is being realized.The amount of physical capital is given as , $K_{p,t}$, while the equilibrium level of capital is given as:

$$\overline{K}_{p,t} = \int K_{p,t} di = K_{p,t} \qquad (10)$$

In the equilibrium output is equal to physical capital $Y_{p,t} = K_{p,t}$ .According to Aghion and Howit(2009)[11], capital can be produced with the advanced and risky technology, and the quantity of produced output(intermediate goods),is x_r , or with some secure but not advanced technology x_Φ .

$$K_{p,t} = x_{r,t-1} = x_{\Phi,r,t-1} \qquad (11)$$

In the Acemoglu and Zilibotti (1997)[12], presumption it is being made that the agents spend in two periods, *t* and *t+1*.But, here we presume that agents are born and they spend in the period t, and that they spend in periodt+1.Here, we also use Ramey, and Ramey (1995) model, but instead of the whole population we use labour force engaged in the process of production.

2. Methodology and data

In this paper we use data from multiple sources and some of the data are being used for 208 regions and countries used in one study[13].The main purpose here is to estimate simple linear panel models, using some of the simple estimators, like pooled OLS, between effects model, maximum likelihood ML panel model. We assume that, $u_{it} \sim IID(0, \sigma_u^2)$ [14].We will use modified Ramey and Ramey (2005), equation:

[11]Aghion, P, Howit,P.(2009),***The Economics of growth***, MIT university press

[12]Acemoglu, Daron,Zilibotti, Fabrizio, (1999). " ***Information Accumulation in Development***," Journal of Economic Growth, Springer, vol. 4(1), pages 5-38, March.

[13]BülentUlaşan, 2012, "***Openness to International Trade and Economic Growth: A Cross-Country Empirical Investigation [Dataset]***", http://hdl.handle.net/1902.1/18245 UNF:5:2bZyPUz4MN/u7sAKORnl5A== Economics: The Open-Access, Open-Assessment E-Journal [Distributor] V3 [Version]

[14]Davidson, R., MacKinnon, J. (2004). ***Econometric Theory and Methods***. Oxford University Press, New York

$$\ln\left(\frac{y_{t+1}}{y_t}\right)_{it} = \beta_0 + \beta_1 \ln(\sigma)_{it} + \beta_2 \ln\left(\frac{I}{\gamma}\right)_{it} + \beta_3 l_{it} + \beta_4 h_{it} + \beta_5 \gamma_{it} + u_{it} \quad (12)$$

In the previous equation $\ln\left(\frac{y_{t+1}}{y_t}\right)_{it}$ represents the growth rate of the output for the whole sample of countries, $\ln(\sigma)_{it}$ represents the volatility of growth, or standard deviation for the growth of output for every country or region in the sample (208 regions), $\ln\left(\frac{I}{\gamma}\right)_{it}$ represents the average level of the investment in every country or region, l_{it} represents the labor force engaged in the production process in every country or region in the sample for the time period from 1960 to 2000. While the h_{it} variable represents human capital, proxy by the average number of years in schooling. While γ_{it} represents the initial level of output. This model is similar to the neo-classical function of MRW model[15], but we augment the function with Black market premium in the 1960's, 70's, 80's, 90's, this variable is proxy for macroeconomics imbalances. Also we later control for current openness, and real openness, and institutional quality. For a robustness check of the results we control by geographic regions, East Asia and the Pacific, Latin American and Caribbean countries, and Sub-Saharan African countries.

3. Econometrics results

In this section we present the results from the econometrics section. At first we present basic Pooled OLS model, presented by the following equation, and then we present results in the table:

$$\ln\left(\frac{y_{t+1}}{y_t}\right)_{it} = \beta_0 + \beta_1 \ln(\gamma)_{it} + \beta_2 \log\left(\frac{Inv}{GDP}\right) + \beta_3 (l)_{it} + \beta_4 \ln(h)_{it} + \beta_5 \ln(n+g+\delta)_{it} + \beta_6 \ln(\sigma)_{it} + u_{it} \quad (13)$$

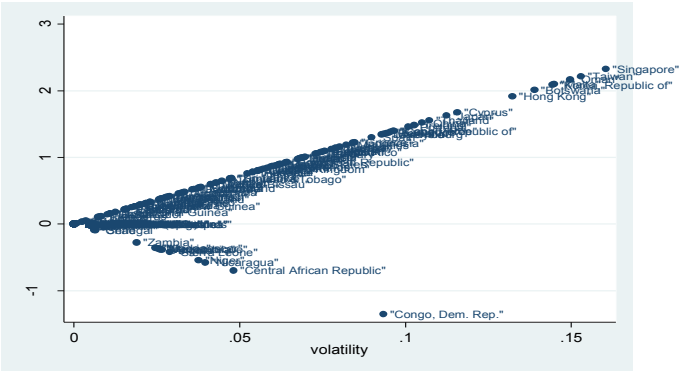
[15]Mankiw,Romer,Weil(1992),***A contribution to the empirics of the economic growth, The quarterly journal of economics***, Vol107,Issue,2 pp.407-437

Table 1 Pooled OLS estimation of the equation (13)

Growth of GDP 1960-2000	Variable definition	Coefficient	t-statistics
LY1960	Initial GDP	-0.18	-3.02
LINV	Investment to GDP	0.21	1.94
LFORCE	Labor force	-0.01	-0.44
LSCH	Human capital	0.17	3.14
LNGD	Convergence rate	-0.49	-1.62
VOLATILITY	Growth volatility	10.92	5.11
Constant	Intercept	0.95	1.83
R^2		0.7895	
Ramsey test H_0:model has no omitted variables		0.4722	

From the Table we can see that all of the signs of the variables are expected from the theory, namely the sign on the initial GDP is negative, the sign on the labour force is insignificant though negative, the sign on the human capital is positive, and the sign of our variable of interest growth volatility is positive as *apriori* expected. The sign on the convergence rate is negative and significant which is also expected from the neo-classical growth theory, due to the fact that underdeveloped countries grow faster according to this theory.In our econometric model Investment variable is being used as proxy for physical capital. This result (about the positive association between growth and volatility) has being graphically depicted on the following graph.

Graph 1 Growth and Volatility association



Next, we continue with analysis and for the robustness check, we use Black Market premium (BMP), this variable is proxy for macroeconomic imbalances in countries. Now, the negative and significant connection between black market premium and economic growth over the period 1960-2000 reflects the adverse relation between macroeconomic imbalances and growth. Although, this variable is significant in 1980's. While, the coefficient on volatility is not very different in size from the previous model when Black market premium was not included.

Table 2 Pooled OLS estimation of the volatility and growth equation augmented with BMP

Model		**1**		**2**		**3**		**4**	
Growth of GDP 1960-2000	**Variable definition**	**Coeff.**	**t**	**Coeff.**	**t**	**Coeff.**	**t**	**Coeff.**	**t**
LY1960	Initial GDP	-0.32	-2.34	-0.19	-2.71	-0.18	-2.89	-0.19	-2.87
LINV	Investment to GDP	0.18	1.48	0.18	1.81	0.18	1.71	0.20	1.84
LFORCE	Labor force	-0.03	-1.96	-0.02	-1.56	-0.02	-1.81	-0.02	-1.68
LSCH	Human capital	0.37	2.39	0.20	2.61	0.19	2.2	0.23	2.56
logBMP60	Black market premium 1960's	-0.53	-1.36						
logBMP70	Black market premium 1970's			-0.19	-1.05				
logBMP80	Black market premium 1980's					-0.16	-2.9		
logBMP90	Black market premium 1990's							-0.10	-1.47
VOLATILITY	Growth volatility	9.35	3.12	10.30	3.99	9.88	3.7	10.04	3.66
Constant		4.05	2.34	2.56	2.72	2.54	3.08	2.64	2.87
F-stat		0.000		0.000		0.000		0.000	
R^2		0.7621		0.7526		0.7696		0.7468	
Ramsey test H_0:model has no omitted variables		0.5016		0.1338		0.3516		0.3617	

Next, we add institutions quality variable in the econometric equation, and real openness measured by the real prices and current openness measured by the nominal prices.

$$\ln\left(\frac{y_{t+1}}{y_t}\right)_{it} = \beta_0 + \beta_1 \ln(\gamma)_{it} + \beta_3 \ln(n+g+\delta)_{it} +$$
$$\beta_3 \ln(\frac{Inv}{GDP}) + \beta_4 (h)_{it} + \beta_5 \ln(ICGR)_{it} \qquad (14)$$
$$+ \beta_6 \ln(l)_{it} + \beta_7 \ln(real/currentopenness) + \beta_8 \ln(\sigma)_{it} + u_{it}$$

Table 3 Between effects model estimation of the volatility and growth equation augmented with measures of openness and institutional quality index [16]

Model Panel between effects estimation		1		2	
Growth of GDP 1960-2000		Coef.	t	Coef.	t
LY1960	Initial GDP	-0.22	-3.17	-0.21	-3.25
LNGD	convergence rate	-0.56	-1.74	-0.58	-1.8
LINV	Investment to GDP	0.25	3.36	0.25	3.42
LSCH	Human capital	0.19	2.51	0.19	2.48
ICGR	Institutional Quality Index based on the ICRG data	0.03	1.99	-0.03	-1.97
LFORCE	Labour force	0.01	0.29	0.01	0.3
ROPEN	Real Openness from Penn World	0.07	0.61		
COPEN	Current Openness from Penn World			0.06	0.74
VOLATILITY	Growth volatility	9.90	7.36	9.94	7.71
CONSTANT	Constant	1.14	1.15	0.99	1.00
R^2(between)		0.7935		0.7939	
F-stat		0.000		0.000	

In the presence for the measure of institutions the coefficient on volatility is somewhat below 10 and significant, the sign on the institutions is positive and significant but of small size 0.03,and t-stat 1.99, while the signs on the other variables are expected, but trade measures in the presence of institutions seems to exert negative association with growth variable. That is we conclude that institutions are

[16]Published by a private international consulting company *Political Risk Services,* this index consists of equally weighting an average of four ICRG components for the years 1984-2000: i) investment profile as a average of three subcomponents namely, contract viability, profits repatriation and payment delays; ii) law and order; iii) corruption; and iv) bureaucratic quality.

more positively associated to growth than trade is. Next we add dummy variables for East Asia and Pacific, Sub-Saharan Africa and Latin America and Caribbean, and the results are presented in the following table.

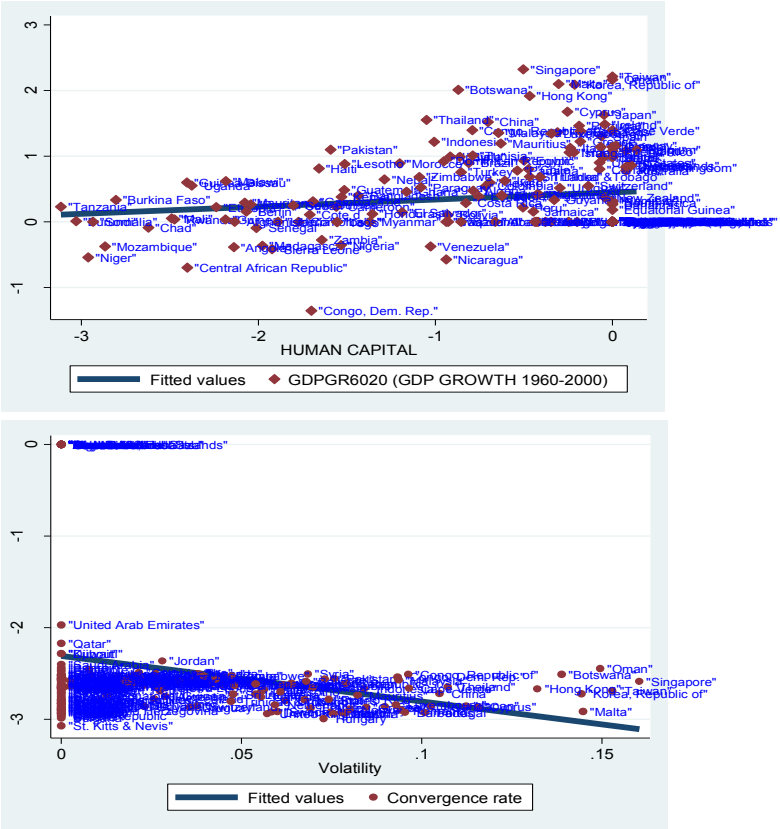
Table 4 Maximum likelihood estimation of the output and volatility equation augmented with dummy variables for East Asia and Pacific, Sub-Saharan Africa and Latin America and Caribbean

Models Maximum likelihood estimation		1		2		3	
Growth of GDP 1960-2000		Coef.	z	Coef.	z	Coef.	z
LY1960	Initial GDP	-0.20	-3.36	-0.21	-3.56	-0.19	-3.23
LNGD	Convergence rate	-0.58	-2.11	-0.54	-1.99	-0.53	-1.92
LINV	Investment to GDP	0.21	3.5	0.21	3.38	0.21	3.49
LSCH	Human capital	0.18	2.56	0.16	2.14	0.18	2.58
ICGR	Institutional Quality Index based on the ICRG data	0.03	2.08	-0.03	-2.09	-0.03	-2.14
LFORCE	Labour force	0.01	0.31	0.01	0.42	0.01	0.36
EAP	Dummy for East Asia and Pacific, S:WB GDN	0.10	1.60				
SSA	Dummy for sub- Saharan Africa			-0.13	-1.61		
LAC	Dummy for Latin America and Caribbean					-0.03	-2.33
VOLATILITY	Growth volatility	10.25	8.73	10.48	9.45	10.55	9.24
CONSTANT	Constant	0.81	0.92	1.02	1.16	0.88	0.99
chi^2		0.000		0.000		0.000	
Number of observations		96		96		96	

Although the three dummy variables appear significant, the sign on the institutions quality variable is positive in the East Asia and Pacific equation, while in the Sub-Saharan Africa and Latin America and

Caribbean is negative. And the volatility of growth is highest in Latin America and Caribbean, similar to Dub-Saharan Africa, which confirms the notion that institutions in this countries failed to provide stability and to reduce the political risks and therefore this countries did not succeed to mitigate social conflicts. Next, we graphically depict the relationship between human capital and growth, volatility and convergence rate.

Graphs 2 and 3 Human capital and GDP growth and Volatility of GDP growth with convergence



From the graphs it can be seen that the association between Human capital and GDP growth is positive, nowadays human capital is widely recognized as one of the main driving forces of GDP growth, while the convergence rate is negatively associated with the standard deviation of growth i.e. volatility. This as conclusion, one can say that volatility lowers convergence, i.e. it lowers the speed of growth, and hence it slows the process of *catching up*, for poorer countries that are trying to catch up with the rich countries.

4. Conclusion

This paper shows to be supportive of the *apriori* knowledge about the link between volatility and growth of the countries. The link between volatility (standard deviation of GDP growth) and GDP growth itself seems to be positive in all of our models. Institutions seems not to be helpful when one wants to reduce the GDP growth uncertainty, i.e. to reduce GDP growth volatility. Dummy variables for East Asia and Pacific, And Sub-Saharan Africa, as well as Latin America and Caribbean countries, proved that East Asian institutions are better than Sub-Saharan Africa institutions and Latin American's or Caribbean institutions. Surprising is the effect of labour force which in most of the models is negative on growth, but in the maximum likelihood model is positive though insignificant.

References

1. Ramey, G., and V. Ramey. (1995). "***Cross-Country Evidence on the Link between Volatility and Growth***." American Economic Review, 85, 1138–1151.
2. Kormendi, R. C. and P. G. Meguire. 1985. "***Macroeconomic Determinants of Growth: Cross- Country Evidence***." *Journal of Monetary Economics* 16 (September): 141–163.
3. Aghion P, Angeletos G, Banerjee A, Manova K.(2005), ***Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment***, Harvard University Department of economics.
4. Aghion, P, Howit,P.(2009),***The Economics of growth***, MIT university press
5. Acemoglu, Daron, Zilibotti, Fabrizio, (1999). "***Information Accumulation in Development***," Journal of Economic Growth, Springer, vol. 4(1), pages 5-38, March.
6. BülentUlaşan, 2012, "***Openness to International Trade and Economic Growth: A Cross-Country Empirical Investigation [Dataset]***", http://hdl.handle.net/1902.1/18245 UNF:5:2bZyPUz4MN/u7sAKORnl5A==Economics: The Open-Access, Open-Assessment E-Journal [Distributor] V3 [Version]
7. Davidson, R., MacKinnon, J. (2004). ***Econometric Theory and Methods***. Oxford University Press, New York
8. Mankiw,Romer,Weil(1992),***A contribution to the empirics of the economic growth, The quarterly journal of economics***, Vol107,Issue,2 pp.407-437
9. Black, Fischer,(1987), ***Business cycles and equilibrium***. Cambridge, MA: Blackwell
10. Grier, Kevin B. and Tullock, Gordon. **"*An Empirical Analysis of Cross-National Economic Growth, 1951-80.*"** Journal of Monetary Economics, September 1989, 24(2), pp. 259-76.
11. Bernanke, Ben S**. "*Irreversibility, Uncertainty, and Cyclical Investment.*"** Quarterly Journal of Economics, February 1983, 98(1), pp. 85-106.